Opportunities for polymer-based nanowires in optoelectronics and nanophotonics

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One-dimensional polymer and hybrid nanostructures, such as nanowires (NWs) and nanotubes (NTs), represent attractive building blocks for nanoscale optoelectronic and photonic devices. They exhibit promising functionalities namely field effect in transistors and sensors, field emission, active waveguiding, optically pumped lasing and photodetection. Recent advances in the synthesis of hybrid nanostructures open the way to investigate and ultimately to control the optical features by the choice of materials and their respective location in complex architectures.

In this scope, we report on the design and study of the (opto)electronic and photonic properties of different polymer-based nanowires and nanotubes. The elaboration of nanowires and nanotubes with different architectures reported in this work has been achieved by template strategies.

Conducting poly(3,4-ethylene-dioxythiophene) PEDOT nanowires were synthesized by electropolymerization confined within nanopores. The effect of the nanowire diameter on the electrical properties has been determined, with a shift from an insulating behavior for 190 nm diameter to a metal-like behavior for the 35 nm one. This has been attributed to molecular and supermolecular improvement induced by the confined synthesis, as shown by spectroscopic studies.[1]

Semi-conducting poly-(p-phenylene-vinylene) (PPV) nanowires and nanotubes were elaborated by a solvent-assisted wetting of nanopores. The study of their photoluminescence PL behaviors has shown that the nanotube exhibit unique PL features: a new band located at 460 nm with a decay time which can be analyzed with a single component. This can be explained by the polymer chain alignment along the NT axis and to inhibited exciton migration.[2] This ability for the template strategy to align polymer chains has been extended to carbon nanotubes (SWNTs) in PPV-SWNT nanocomposite nanofibers. It results in an enhancement of the photoconductivity by a factor larger than 150.[3] Finally, the magnetic manipulation of luminescent NWs was demonstrated by synthesizing a nickel core within a PPV shell.[4]

Recently, we develop an original concept to restrain the charge and energy transfer between two luminophores for controlling the color of emission nanowires.[5] This has been achieved by a spectral and spatial control of the two luminophores. A coaxial geometry results in yellow NWs while the core is a nanocomposite (metal-compound clusters of $Mo_6Br_8F_6$ within a PMMA matrix) with a red PL signal and the shell is green-emitting PPV.

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